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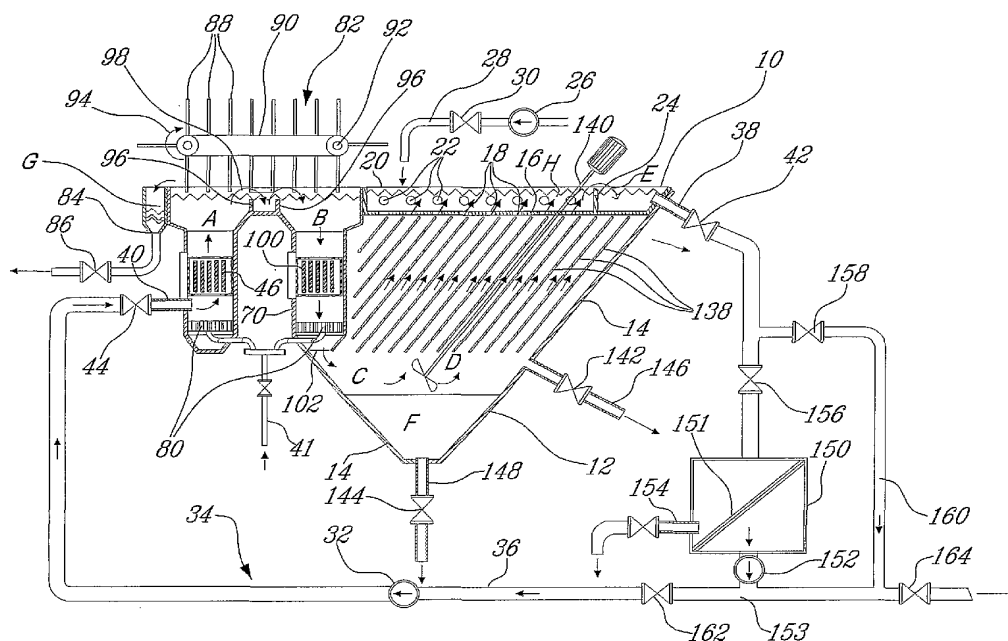
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(54) Title: METHOD AND APPARATUS FOR THE ELECTROCHEMICAL TREATMENT OF CONTAMINATED AQUEOUS MEDIA



(57) Abstract: An apparatus (10) for electrochemical purification of a contaminated aqueous medium comprises at least one electrochemical reactor (A,B) connected in fluid flow communication to a settling chamber (D). A re-circulation system (34) is provided for causing at least a portion of the aqueous medium to flow back into the electrochemical reactor (A, B) after the contaminated aqueous medium has been treated and at least partially cleaned in the settling chamber (D).



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METHOD AND APPARATUS FOR THE ELECTROCHEMICAL  
TREATMENT OF CONTAMINATED AQUEOUS MEDIA

BACKGROUND OF THE INVENTION

5    Field of the Invention

The present invention relates to an apparatus and a method for purifying contaminated liquids and, more particularly, to a method and an apparatus for the electrochemical treatment of contaminated liquids, such as livestock and industrial wastewater.

10   Description of the Prior Art

It is known to remove contaminants from wastewater by flowing the contaminated water through an electrochemical reactor, such as an electrofloatation reactor or an electrocoagulation reactor.

One problem with known electrochemical reactors is that the  
15   electrodes thereof, which may be soluble or insoluble, often get fouled by pollutants and oxidation products during the electrolysis process. This lowers capacity and reduces efficiency. Attempts have been made to overcome this problem.

For instance, United States Patent No. 4,338,178 issued on July 6,  
20   1982 to Efimov et al. discloses a vertical electrocoagulation cell mounted directly under a horizontal electrofloatation cell. A "pure" electrolyte is injected under the electrocoagulation cell to provide for the separation of the effluent and the sacrificed consumable electrodes of the electrocoagulation cell in order to prevent fouling of the consumable electrodes. The unit disclosed in this patent has the  
25   disadvantage of requiring a great amount of "clean" water to operate under normal condition. Furthermore, the application is limited to small process unit.

United States Patent No. 5,558,755 issued on September 24, 1996 to Gardner-Clayson et al. discloses a tubular electrochemical cell with non-consumable electrodes. The apparatus includes a fluidized bed of metallic  
30   particles to promote turbulence inside the electrochemical cell and, thus, improve current efficiency. The tubular cells will be most likely difficult to replace and

repair. Furthermore, such an apparatus is not suitable for treatment of effluent having a high concentration of organic or colloid matters. Indeed, the metallic particles will suffer from thin film depositions to its surface. Such a phenomenon may impair the coagulation to proceed successfully.

5           European Patent number EP 0794157 issued to Ming Shing discloses an electrochemical cell in which the effluent to be treated flows upwardly through a tortuous S-shaped path. Because high pressure of water is required to prevent clogging, the electrode blades must be tightly sealed. It is obvious that electrode maintenance and replacement are time consuming.  
10   Moreover, negative pressure occurs in the dead zone of the flow path. This can result in an excessive gas buildup.

A common shortcoming of all the foregoing prior art apparatus is the buildup of metal oxide layers on the anode surfaces. These layers may also lead to an excessive increase of the ohmic resistance of the electrochemical cell  
15   and therefore to a frequent interruption of the electrochemical process. On the other hand, if the treatment lasts over an optimal point, the solubilization of phosphate raises, and therefore the yield of the electrochemical treatment falls.

The foregoing disadvantages are overcome by the present process and apparatus. Additionally, the proposed method and apparatus achieve other  
20   advantages discussed more fully below.

#### SUMMARY OF THE INVENTION

It is therefore an aim of the present invention to prevent the electrodes of an electrochemical reactor from fouling.

It is also an aim of the present invention to provide an  
25   electrochemical apparatus which is adapted to efficiently remove suspended solids, colloids, organic matters, pathogens, particulate and soluble phosphorus that are present in wastewater.

It is a further aim of the present invention to provide an electrochemical reactor which is simple of construction and which is provided  
30   with easy removable electrode plates for maintenance and cleaning.

It is a further aim of the present invention to provide a new electrochemical reactor with high specific surface area and low investment and operation costs.

5 It is a still further aim of the present invention to provide an electrochemical cell which is simple to manufacture, install and connect to an external source of electricity.

Waste water generally contains negatively charged colloids organic particles which are not easy to settle and thereafter to remove. It is a further object of one embodiment of the present invention to provide reaction chambers  
10 to precede either simultaneity or separately with charge neutralization, coagulation, flocculation and sedimentation in compact equipment. The charge net carried by each particles are neutralized with the anions released in the anode. Once charge neutralization takes place several particles come together which will result into coagulation. Flocculation is the stage whereby the destabilized  
15 particles are induced to collect into larger aggregates. It is followed by rapid settling in a sedimentation chamber.

It is also a further object of the present invention to provide an electrochemical apparatus which can operate in a small room area.

It is also a further object of the present invention to provide a  
20 suitable arrangement of electrofloatation reactor, electrocoagulation reactor, settling chamber, collecting device for relatively cleaned water and a back recirculation of this cleaned water to electrochemical cell reactors in order to cope electrodes fouling.

It is also a further object of the present invention to provide a  
25 method and apparatus of obtaining feedbacks on the electrode condition during the electrolysis process.

Therefore, in accordance with the present invention, there is provided an apparatus for electrochemical purification of a contaminated aqueous medium, comprising at least one electrochemical reactor and a re-circulation  
30 system for causing at least a portion of the aqueous medium to flow back into the electrochemical reactor after the contaminated aqueous medium has been treated.

In accordance with a further general aspect of the present invention, there is provided a method for separating contaminants from a contaminated effluent, comprising the steps of: feeding the contaminated effluent to be treated into an apparatus comprising at least one electrochemical reactor and  
5 a re-circulation system, submitting the contaminated effluent to a succession of electrochemical treatments by re-circulating the contaminated effluent through the apparatus for a period of time sufficient to obtain an agglomeration of the contaminants contained in the effluent, and evacuating the agglomerated contaminants.

10 In accordance with a still further general aspect of the present invention, there is provided an electrochemical cell, comprising a set of electrode plates mounted between a pair of opposed non-conductive walls defining on respective inner faces thereof a series of longitudinally spaced-apart parallel slots for receiving opposed longitudinal edges of the electrode plates, thereby holding  
15 the electrode plates in a parallel spaced-apart relationship to one another.

According to a further general aspect of the present invention, the contaminated liquid is submitted to a succession of electrochemical treatments and the contaminants are separated from the liquid by floatation and by gravity settling. The liquid to be treated is re-circulated through the apparatus until the  
20 level of contaminants contained in the liquid reaches a predetermined level. Following the application of the electrochemical treatments, a portion of the contaminants is carried up by floatation and is extracted in the form of foam. Another portion of the contaminants is agglomerated (i.e. flocculated and coagulated) in the form of sludge. The sludge is preferably separated from the  
25 liquid by a gravity settling process.

The present invention provides for the reduction of the concentration of phosphorous in the contaminated liquid to a level as low as 1 mg/l, thereby allowing the purified liquid to be discharged back into the environment. The present invention also provides for the oxidation of the non-  
30 biodegradable organic residual loads, and the destruction of pathogenic germs.

The present treatment method is particularly effective for effluents which have gone through a preliminary biological purification treatment.

According to a further general aspect of the present invention, there is provided an apparatus for performing the above-described purification treatment method. The apparatus may comprise a main tank equipped with electrofloatation and electrocoagulation reactors and defining a gravity settling chamber, and a system for re-circulating the liquid to be treated through the apparatus. The re-circulation of purified liquid through the reactors greatly contributes to prevent the electrodes of the reactors from fouling. The recirculation of the liquid is also advantageous in that the size of the apparatus can be kept to a minimum and the manufacturing costs thereof can be reduced. Finally, by having more than one passage of the effluent to be treated through the apparatus, it has been found that economic efficiency and the purification rate of the process can be increased.

The present invention provides for the application of a series of complex electrochemical treatments based on the combined effect of electrofloatation, electrocoagulation and electroflocculation by ensuring an optimal re-circulation period of the contaminated liquid to be treated as a function of its characteristics and the degree of purification to be obtained. By controlling the interaction, the duration and the intensity of each step of the treatment and by re-circulating the contaminated liquid, it becomes possible to obtain a significant improvement of the agglomeration effects on the contaminants, thereby facilitating removal thereof through the use of floatation and settling techniques. It also becomes possible to take advantage of the effect of the various electrochemical reactions to promote the oxidation of the organic residual and non-biodegradable loads and the destruction of the pathogenic germs.

According to a more specific aspect of the present invention, there is provided a method for treating a contaminated aqueous effluent, comprising the steps of: feeding the contaminated aqueous effluent to a treatment apparatus comprising at least one electrochemical reactor, a settling chamber and an effluent re-circulating system, submitting the effluent to a succession of

electrochemical treatments by re-circulating the effluent through the apparatus for a predetermined number of cycles so as to obtain a separation and an agglomeration of the contaminants in the form of foam and sludge, removing from the effluent the foam produced in the electrochemical reactor and the sludge  
5 settled in the settling chamber, and collecting the clean effluent into a reservoir.

According to another feature of the present invention, the apparatus is provided with a programmable control system for controlling the circulation of the effluent through the apparatus, the number of passes thereof through the various treatment sections of the apparatus as well as the intensity of  
10 the electric field to be generated in the electrochemical reactors of the apparatus as a function of the degree of contamination of the effluent.

According to a more specific construction of the present invention, the electrochemical reactors are realized by a combination of the two following variants:

15 An electrochemical reactor with insoluble electrodes, such as stainless steel grids or plates, titanium grids or plates or any other corrosion-proof conducting plates. The connection of the electrodes to a source of electric current results in the generation of hydrogen and oxygen bubbles. The main role of this type of reactor is to create a floatation reaction with the formation of foam at the  
20 surface of the liquid to be treated. A great portion of the contaminants present in the liquid to be treated will be contained in the formed foam. It is also possible to take benefit from the oxidation phenomenon of the organic matter in order to improve the efficiency of the overall purification process. For amplifying the flocculation process and the oxidation effects, an injection of fine air bubbles can  
25 be added to the flow of contaminated liquid passing through the reactor.

An electrochemical reactor with soluble electrodes (sacrificial consumable electrodes), such as steel, aluminum or iron electrode plates. In addition of generating hydrogen and oxygen bubbles, the connection of the soluble electrodes to a source of electric current is associated with the production  
30 of electrode dissolution products with which the contaminated liquid is mixed as it flows through the reactor. The main role of this type of reactor is to produce



metallic cations ( $\text{Fe}^{2+}$ ,  $\text{Al}^{3+}$ ), which contribute to destabilize negatively charged colloidal suspension. Furthermore, in a lightly alkaline reactional environment (pH comprised between 7.1 and 8.5), these cations are immediately transformed into their corresponding hydroxides which by their reactivity provide for a co-precipitation of the soluble hydroxides and phosphorous particles. The injection of fine air bubbles in the stream of the contaminated liquid which flows through the reactor is associated with an agitation of the liquid which contributes to prevent fouling of the electrodes and to oxidize ferrous ions to ferric ions.

According to a more specific construction of the present invention, the settling chamber of the apparatus comprises a vertical reservoir having a generally rectangular cross-section and at least a pair of sidewalls which are inclined at about 60 degrees. The settling chamber may further include a set of lamellar plates which are also inclined at about 60 degrees to facilitate the decantation.

According to a more specific construction of the present invention, the re-circulation system of the apparatus comprises a pump mounted in a re-circulation line. A series of weir plates are preferably provided between the various sections of the main tank to control the flow of the effluent through the apparatus.

In accordance with another aspect of the present invention, a mechanical separator, such as a filtration membrane is integrated into an electrochemical treatment device. A re-circulation circuit is provided for causing at least a portion of the effluent leaving the reactor to be redirected therein. A switching mechanism is preferably provided for selectively isolating the mechanical separator from the re-circulation circuit, thereby allowing the effluent to be only re-circulated through the reactor. At the beginning of the purification process, the electrochemical reactor will most likely be used alone, whereas at the end of the process both the electrochemical reactor and the mechanical separator will be used to treat the effluent.

In accordance with a still further general aspect of the present invention, there is provided an electrochemical treatment device for treatment of a

contaminated effluent, comprising a recirculation circuit for circulating said effluent through a closed loop, an electrochemical reactor and a mechanical separator integrated to said closed loop for gradually purifying the effluent each time the effluent is circulated therethrough.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Having thus generally described the nature of the invention, reference will now be made to the accompanying drawings, showing by way of illustration a preferred embodiment thereof, and in which:

Fig. 1 is a schematic vertical cross-section view of an apparatus for  
10 the electrochemical treatment of contaminated liquids in accordance with a preferred embodiment of the present invention;

Fig. 2 is a top plan view of the apparatus shown in Fig. 1;

Fig. 3 is a perspective view of one half of the apparatus shown in  
Fig. 1;

15 Figs. 4a to 4c are perspective view of an electrocoagulation cell in accordance with a preferred embodiment of the present invention;

Fig. 5 is a perspective view of an electrocoagulation cell in accordance with a second embodiment of the present invention;

Fig. 6 is a perspective view of an electrofloatation cell in  
20 accordance with a preferred embodiment of the present invention;

Figs. 7a and 7b are perspective view of an electrofloatation cell in accordance with a second embodiment of the present invention;

Figs. 8a and 8b are graphic representations of the evolution of the residual phosphorus during the purification process of synthetic water;

25 Fig. 8c is a graphic representation of the evolution of the pH of the synthetic water during the purification process thereof; and

Fig. 9 is an example of a graphic that can be generated by the controlled system of the apparatus to determine the condition of the electrodes.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

30 Fig. 1 illustrates an electrochemical treatment apparatus 10 suited for separating contaminants from a contaminated aqueous medium, such as

livestock wastewater (e.g. liquid manure) and industrial wastewater. The apparatus 10 is particularly suited for purifying wastewater from livestock or agricultural industries.

As shown in Figs. 1 to 3, the apparatus 10 comprises a top open  
5 ended main tank 12 divided into a plurality of compartments or chambers interconnected in fluid flow communication. More specifically, the main tank 10 defines a first reactor chamber A, a second reactor chamber B, a gravity settling chamber D having a bottom contaminant settling zone F, a clear liquid collection chamber H provided at the top of the gravity settling chamber D for receiving  
10 clear liquid therefrom, a clear liquid disposal chamber E connected in fluid flow communication to the collection chamber H for receiving clear liquid therefrom, and a foam receiving chamber G for receiving the foam resulting from the passage of the contaminated aqueous medium through the first and second reactor chambers A and B. The main tank 12 is preferably formed from metal sheets and  
15 the reactor chambers A and B are preferably lined with an electric insulating material, such as a plastic material or from metal sheets with plasticization. The main tank 12 can be also made of concrete.

As shown in Figs. 1 and 3, the settling chamber D is provided with a pair of sidewalls 14 inclined at an angle comprised between 45 and 60 degrees.  
20 The collection chamber H has an open bottom wall 16 for allowing liquid to pass from the settling chamber D into the collection chamber H. According to a preferred embodiment of the present invention, the open bottom wall 16 is provided in the form of a perforated plate covering part of the settling chamber D and defining a plurality of inlet openings 18. The collection chamber H further  
25 includes a pair of sidewalls 20 defining a series of spaced-apart openings 22 adapted to be located under the level of liquid for ensuring an intake of clear liquid and prevent the presence of foam in the disposal chamber E, as will be seen hereinafter. The collection chamber H is provided at one end thereof with a weir plate 24 for allowing the clear liquid to flow at a given rate from the collection  
30 chamber H into the disposal chamber E.

As shown in Fig. 1, a pump 26 is provided for feeding the aqueous medium to be treated into the main tank 12 via a delivery pipe 28. A valve 30 is provided for adjusting the flow of contaminated aqueous medium through the delivery pipe 28. Once the main tank 12 has been filled up so that the level of contaminated aqueous medium rises above the openings 22 in the sidewalls 20 of the collection chamber H, as shown in Fig. 1, the pump 26 is shut down and a pump 32 forming part of a re-circulation system 34 is activated to circulate the aqueous medium through the apparatus 10.

As shown in Fig. 1, the pump 32 of the re-circulation system 34 is mounted in a re-circulation line 36 having an inlet pipe 38 connected in fluid flow communication with the disposal chamber E and an outlet pipe 40 connected in fluid flow communication with a bottom end portion of the first reactor chamber A. First and second valves 42 and 44 are provided upstream and downstream of the re-circulation pump 32 for controlling the flow of the aqueous medium through the re-circulation line 36.

The aqueous medium to be treated is first supplied to the bottom of the first reactor chamber A. According to a preferred embodiment of the present invention, the aqueous medium is caused to flow upwardly through a non-consumable electrofloatation cell 46 removably mounted in the first reactor chamber A. The first reactor chamber A and the electrofloatation cell 46 form an electrofloatation reactor in which a portion of the contaminants contained in the aqueous medium to be treated is transformed into foam, as will be seen hereinafter.

As shown in Fig. 6, the electrofloatation cell 46 includes a pair of horizontal electrode plates 48, each of which is sandwiched between a base plate 50 and a clamping plate 52 defining a central rectangular opening. The base plate 50 and the clamping plate 52 of each set are drawn one towards the other by four clamping screws 54. Four plastic cap screws 56 and four plastic nuts 58 are provided for holding the two sets of clamping and base plates 50 and 52 together. Four plastic washers 60 are provided between the two sets of plates about the cap screws 56 to isolate the electrode plates 48 from one another. Electric connectors

(not shown) are provided for allowing the so assembled electrofloatation cell to be fed with dc current or alternating current. Each base plate 50 is provided with a mounting arm 62 by which the electrofloatation cell can be releasably secured to the sidewall of the first reactor chamber A. Each electrode plates 48 are  
5 preferably provided in the form of a stainless steel screen.

Alternatively, as shown in Figs. 7a and 7b, the electrofloatation cell 46 can take the form of a series of parallel and vertically oriented spaced-apart monopolar plates 64 depending from a pair of laterally spaced-apart support members 66 removably mounted to an inner surface of a closure plate 68 adapted  
10 to be removably bolted to a sidewall of the first reaction chamber A to close an opening defined therein. In this way, the electrofloatation cell 46 can be readily removed as a unit from the first reactor chamber A through the opening normally closed by the closure plate 68. The supports 66 are made of an electrically  
conducting material and are connected at respective proximal ends thereof to  
15 electric connectors 70 mounted to the closure plate 68. As shown in Fig. 7b, each monopolar plate 64 is provided at an upper edge thereof with a pair of laterally spaced-apart internally threaded cylinders 72 for threaded engagement with  
corresponding threaded pins 74. As shown in Fig. 7a, the pins 74 extend through longitudinally extending slots 76 defined in the support members 66 and are  
20 provided with respective head portions 78 for allowing the pins 74 to hang from the support members 66 once inserted in the slots 76 thereof. It is understood that the pins 74 and the cylinders 72 are made of electrically conducting material for  
allowing current to be fed to the plates 64 via the support members 66.

As shown in Fig. 1, an air diffuser 80 is provided in the bottom  
25 portion of the first reactor chamber A underneath the electrofloatation cell 46 for injecting compressed air in the form of fine bubbles into the first reaction chamber A. By feeding the electrofloatation cell 46 with dc current or alternating  
current, oxygen and hydrogen micro-bubbles are generated. (diameter of about 10  $\mu\text{m}$ ) The oxygen and hydrogen bubbles, like the injected air bubbles, rise to the  
30 surface bringing with them the suspended and colloidal particles contained in the aqueous medium, which flows in the same direction (co-current flow) as the

bubbles generated in the first reactor chamber A. The suspended and colloidal particles are agglomerated and gradually transformed into foam at the surface of the aqueous medium. As shown in Fig. 1, a foam remover 82 is provided for directing the foam formed at the surface of the aqueous medium into the foam receiving chamber G, wherein the foam is drained via a drain 84 operated by a valve 86. The foam remover 82 comprises a plurality of fins 88 extending outwardly at right angles from an endless belt 90 extending over a pair of rollers 92, one of the rollers 92 being driven in rotation for driving the belt 90 in the direction indicated by arrow 94.

10           The removal of the suspended and colloidal particles allows the aqueous medium to progressively become clearer. In addition of trapping the particles and bringing them to the surface, the oxygen bubbles act as an oxidant and allows the organic molecules to split up, thereby facilitating the oxidation thereof. The hydrogen formed at the cathode of the electrofloatation cell 46 is a  
15           reducer which provides for the hydrogenation of the organic molecules, thereby rendering the organic molecules less resistant to oxidation.

          The air diffuser 80 could be replaced by a commercially available ultrasound generator mounted at the bottom of the reactor chamber A to emit sound vibrations to cause dirt accumulated on the electrode plates to fall  
20           therefrom, thereby preventing fouling of the electrodes.

          As shown in Figs. 1 to 3, the aqueous medium is directed from the top open end of the first reactor chamber A into the top open end of the second reactor chamber B. The flow of aqueous medium between the first and second reactor chambers A and B is controlled by a pair of weir plates 96 over which the  
25           aqueous medium has to flow to pass from the first reactor chamber A into the second reactor chamber B. As indicated by arrows 98 in Figs. 1 and 3, the aqueous medium is circulated downwardly through the second reactor chamber B, i.e. in a direction opposite to the flow of aqueous medium in the first reactor chamber A. As shown in Figs. 1 and 2, the second reactor chamber B houses an  
30           electrocoagulation cell 100 through which the aqueous medium is passed

vertically downwardly before flowing into the gravity settling chamber D via an outlet opening 102 defined at the bottom of the second reactor chamber B.

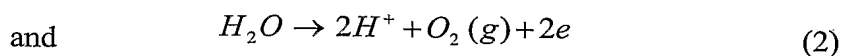
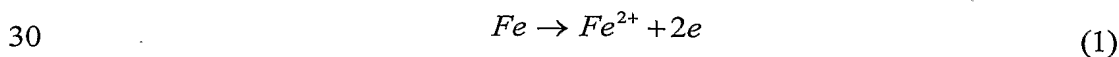
As shown in Figs. 4a, 4b and 4c, the electrocoagulation cell 100 comprises a plurality of side-by-side soluble electrode plates, including  
5 monopolar steel plates 104 and bipolar steel plates 106 housed in spaced-apart relationship in an open ended casing 108 comprising a back wall 110, a pair of sidewalls 112 and a front wall 114. The front and back walls 110 and 114 are provided on respective inner surfaces thereof with a plurality of laterally-spaced apart vertical slots 116 for respectively receiving the front and rear longitudinal  
10 edges of the electrode plates. The back wall 110, the front wall 114 and the sidewalls 112 are made of an insulating material, such as plastic, and are glued, screwed or otherwise secured together in a box-like configuration. The front plate 114 defines a series of through holes 115 for receiving a corresponding series of threaded connectors 117 extending forwardly from the supply bars 119 secured to  
15 the front longitudinal edges of the monopolar plates 104. As shown in Fig. 4c, each supply bar 119 is secured to an associated monopolar plate 104 by means of screws 121. The supply bars 119 are preferably made of brass or bronze. A front cover plate 118 provided with a series of sealing plugs 120 is adapted to be removably mounted to the sidewall of the second reaction chamber B to enable  
20 ready access to the electrocoagulation when need be. The threaded connectors 117 are adapted to extend through the sealing plugs 120 for allowing the electrode plates to be connected to a source of current external to the second reactor chamber B.

Fig. 5 illustrates a second embodiment of an electrocoagulation  
25 cell which includes a set of soluble electrode plates, including monopolar steel plates 122 and bipolar steel plates 124, received between a pair of plastic plates 126 having a series of slots 128 defined in respective inner facing side thereof for receiving opposed longitudinal edges of the soluble electrode plates. The monopolar plates 122 are electrically connected in pairs by engagement of iron  
30 bars 130 with the hooks 132 provided at respective upper edges of the monopolar plates 122. Each iron bar 130 is bolted at one end thereof to an associated

connector 134, which is in turn, connected to a source of current (not shown). The plastic plates 126 are beveled at the bottom end thereof for allowing the electrocoagulation cell illustrated in Fig. 5 to be lowered into the second reaction chamber B and seated in position therein by engagement of the plastic plates 126 with the inner surface of the second reactor chamber A. In this way, the electrocoagulation cell can be easily removed from and installed in the second reactor chamber B via the top open end thereof and that without the use of any tool.

As shown in Fig. 1, pressurized air is fed into the bottom of the second reactor chamber B via the air diffuser 80. The aqueous medium flows in counter-current to the ascending movement of the air bubbles and the oxygen and hydrogen bubbles formed in the second reactor chamber B. Indeed, by feeding dc current or alternating current to the electrocoagulation cell 100, oxygen and hydrogen micro-bubbles (diameter of about 10  $\mu\text{m}$ ) are generated and these micro-bubbles, while rising to the surface in counter-current to the flow of contaminated aqueous medium, bring with them some of the suspended and the colloidal particles which are still present in the aqueous medium. The suspended and colloidal particles are agglomerated at the surface of the aqueous medium and gradually transformed into foam. As for the foam generated in the first electrochemical reactor, the foam generated in the second electrochemical reactor is removed by the foam remover 82.

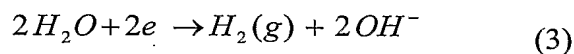
The electrocoagulation cell 100 produces major coagulation and flocculation effects on the contaminants contained in the aqueous medium. At the electrocoagulation cell 100, anodic and cathodic reactions as well as homogenous phase reactions occur simultaneously. At the anode where the electrons are directed, the oxidation reactions occur at the boundary reactional layer. The electrons from the boundary layer are picked up by the anode and directed to an external circuit (not shown). In the case of an iron electrode, the following reactions occur:



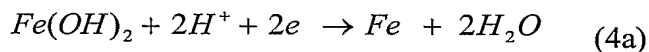


The first equation (1) is the reaction of the dissolution of the anode (iron material) and is the main source of ferrous ions in the second reactor. This reaction is observed when the solution in the reactor turns to green. The other  
 5 equation (2) is the parasite reaction of the evolution of the oxygen due to the electrolysis of the water. At the cathode, where the electrons are supplied, the reduction reactions occur at the boundary layer of the electrodes. The third reaction (3), namely the evolution of the hydrogen due to the electrolysis of the water is defined as follows:

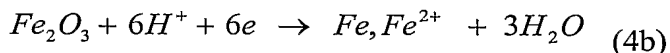
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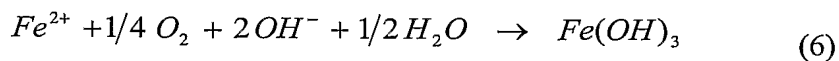
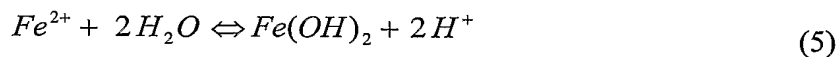
The experimental observation of the slow evolution of the pH at the beginning of the reaction shows that another cathodic reaction takes place in  
 15 parallel. This other reaction corresponds to the dissolution reaction of the oxides or of the iron hydroxides on the electrode plates. This reaction would be defined as follows:



20 or under the form of:



Hydrolysis reactions of  $Fe^{2+}$  ions (reaction 5) also occur in the  
 25 homogenous phase. The  $Fe^{2+}$  ions are oxidised by the dissolved oxygen (reaction 6) and the phosphates are subject to a precipitation reaction:



30

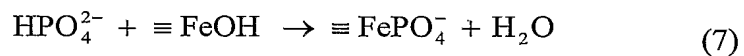
Reaction (5) occurs when the pH of the solution reaches the pH of

precipitation, i.e. : 
$$C_{H^+} \leq \sqrt{\frac{K_{sp}}{C_{Fe^{2+}}}}$$
 where  $K_{sp}$  is the product of solubility of  $Fe(OH)_2$  and  $C_{Fe^{2+}}$  is the concentration of  $Fe^{2+}$ .

5                      Reaction (6) represents the oxidation of the ferrous ions by dissolved oxygen in the form of ferric hydroxide precipitate. The change of colour of the solution from green to brown or light amber is indicative of the presence of this reaction:

The soluble phosphates contain in the aqueous medium to be  
10    treated are mainly in the form of orthophosphates ( $HPO_4^{2-}$  and  $PO_4^{3-}$ ). The phosphates are eliminated by the adsorption thereof on the iron hydroxides.

The main hypothesis for the removal of phosphorus in the presence of an electric field is the adsorption of the phosphorus on the hydroxide surface followed by a surface reaction to form a complex Fe-P. This reaction can be  
15    defined as follows:



In the event of increased pH, the formed Fe-P complex will be  
20    destabilised by the competitive adsorption of the  $OH^-$  ions and the phosphorus will be rejected back in the solution. Therefore, the treatment must be stopped when the optimal pH is reached in order to prevent the phosphorus from being released back into the solution to be decontaminated. Corresponding optimal pH and reaction time are calculated from a kinetic model where electrochemical, the  
25    initial pH, the electric conductivity, the phosphate concentration, and the concentration of suspending particles are previously known. Optimal values of the time reaction and pH are settled in the automatic system.

The passage of the electric current in the electrocoagulation cell  
100    also generates  $Fe^{2+/3+}$  cations. These cations destabilise the negative charges  
30    of the colloids, thereby providing for a better flocculation of the colloids.

Furthermore, by working at an optimal pH, the cations form some hydroxide flocs  $\text{Fe}(\text{OH})_n$  ( $n = 2$  or  $3$ ), which precipitate, adsorb and attract the soluble and organic phosphorus contained in the aqueous medium to be treated.

It is pointed out that according to one feature of the present invention, the electrofloatation cell 46 and the electrocoagulation cell 100 can be interchangeably mounted in either one of the first and the second reactor chambers A and B. In this way, the electrofloatation treatment could be done with the contaminated aqueous medium flowing in counter-current to the oxygen and hydrogen bubbles and the electrocoagulation treatment could be done with the contaminated aqueous medium flowing in co-current to the oxygen and hydrogen bubbles.

It is also pointed out that the settling or sedimentation chamber D could be placed between the first and second reactor chambers A and B. Also, the settling chamber could be provided in the form of an individual concrete sedimentation tank.

At its exit from the second reactor chamber B, the aqueous medium flows in the form of a jet through a turbulence zone C in the settling chamber D. As shown in Figs. 1 and 3, a set of spaced-apart parallel smooth plates 138 inclined at approximately 60 degrees is preferably removably mounted in the settling chamber D. The plates 138 act as a mechanical separator. The aqueous medium loaded with iron hydroxide particles and other flocs is subject to decantation while rising to the surface of the settling chamber between the plates 138. A mechanical agitator 140 is provided to ensure an optimal mixing ratio in the flocculation zone of the settling chamber D. Progressively, the particles will settle to the bottom F of the settling chamber D in the form of sludge and the clear liquid will rise to the surface where the collection chamber H ensures its discharge into the disposal chamber E. The openings 22 in the sidewalls of the collection chamber H will prevent the foam formed during the purification process from being discharged into the disposal chamber E.

It is noted that the plates 138 could be replaced by a standard ultrafiltration unit.

As shown in Fig. 1, first and second valves 142 and 144 are respectively connected to first and second outlet conduits 146 and 148 for respectively discharging the clear liquid and the sludge from the settling chamber D.

5           A mechanical separation system 150 is preferably selectively combined to the electrochemical reactors A and B. The separation system can be integrated in the re-circulation system 34 or, alternatively, into the settling chamber D. The separation system 150 can be used as an alternative to the plates 138 or in addition thereof.

10           Indeed, as shown in Fig. 1, the treated liquid collected in the disposal chamber E is selectively directed into the separation system 150 or into a bypass conduit 160. At the beginning of the treatment process the filtration liquid is typically bypassed by closing valve 156 and opening valve 158. Later on during the treatment process, when the concentration of solid matter in the liquid  
15 falls under a predetermined threshold, the valve 156 is opened to allow the liquid to flow through the separation system 150 before being either pumped back into reactor A by pump 32 or directed to an outlet of the apparatus10 through valve 164. Both valves 156 and 158 can be opened at the same time so that only a portion of the total flow is processed through the supplemental separation system  
20 150.

          The separation system 150 can be provided in the form a separation system, such as a hydrocyclone, a particle filtration unit, a membrane filtration unit, etc. The separation system, 150 may comprise a membrane module 151, a suction pump 151, and a concentrate outlet line 154 that can be connected  
25 to a backwash module (not shown) when it is desired to wash the separation system 150. The membrane module 151 preferably has an average pore size between 0.0002 $\mu$ m and 50 $\mu$ m and more preferably have an average pore size between 0.0005 $\mu$ m and 1  $\mu$ m. Membranes manufactured by Hydranautics under the Trade Mark ESPA 1 to 5 series, HydraCap 40-60 series may be used. As an  
30 option, immersed membranes may replace the plates 138 in the settling chamber

D, suitable membranes include for example those manufactured by Zenon Environmental Inc (ZeeWeed® 500 series), by Mitsubishi or by Kubota.

The suction pump 152 creates a transmembrane pressure across the membranes of the module 151 resulting in the rejection of bacteria or suspended solids. The concentrate is evacuated through line 154. The liquid pumped through the membranes by the suction pump 152 permeate to the permeate line 153. If it is desired to evacuate the filtered liquid, valve 162 is closed and valve 164 is opened. However, if it is desired to re-circulate the filtered liquid through the reactors A and B and the settling chamber D in a closed loop circuit until the level of contaminant contained in the aqueous medium reaches an acceptable level, valve 162 is opened and valve 164 is closed.

The recirculation of "clear" liquid through the reactor chambers A and B advantageously prevents fouling of the electrode plates and clogging of the inter-electrode spaces by the impurities contained in the contaminated aqueous medium. The injection of pressurize air below the electrochemical cells 46 and 100 also contributes prevent fouling of the electrode plates. Pressurized air could also be injected into the settling chamber D for allowing oxidation of ferric and ferrous ions.

Once the desired level of purification has been reached, the recirculation pump 32 is shut down and the valves 142 and 144 are opened. The purified liquid is then discharged via outlet conduit 146 and the sludge formed during the purification process is discharged via outlet conduit 148.

The operation of the apparatus 10 is controlled by an automated control unit (not shown). In this way, the operation of the recirculation pump 32, the suction pump 152, the valves 42, 44, 142, 144 156, 158, 162 and 164 and the electrochemical cells 46 and 100 can be automatically controlled to obtain the desired level of decontamination. More specifically, the control unit is adapted to control the circulation of the effluent through the apparatus 10, the number of passes thereof through the various treatment sections of the apparatus as well as the intensity of the electric field to be generated in the electrochemical reactors as a function of the degree of contamination of the effluent.

Experimental trials have been conducted in two steps:

- 1) Electrochemical tests on a synthetic effluent
- 5           2) Electrochemical tests on a secondary effluent originating from biological treatments

1. Electrochemical tests on a synthetic effluent:

10           These tests were conducted for establishing the basics of the phenomenologic of the reduction of the amount of the phosphorous by electrochemical reactions through the use of soluble anodes. Synthetic water (tap water with phosphorous salt and sodium salt) was used to carry on the experimentation.

15           The experimental conditions are summarized in Table 1. The results are presented in Figs. 8a, 8b and 8c. Fig. 8c illustrates the pH evolution and Figs. 8a and 8b illustrate the evolution of phosphorus in function of the treatment time. These results show that the virtual removal model of phosphorus is representative of the reality. On the other hand, the model can be used to  
20           predict the optimum reaction time within which residual phosphorous is at its minimal value ( $\leq 1$  mg-P/L).

2. Tests on effluents originating from biological treatments:

25           Table 2 shows the results at the optimal rates of phosphorus removal. These experimental results are in accordance with the phenomenologic model (not shown) to predict the performance according to the operating conditions (current intensity, reaction time and the electric conductivity) and the configuration of the electrochemical cell. The global purification tendency can be  
30           predicted with the proposed phenomenologic model. One of the major advantages of the present invention is the safe scale-up of the process.

From table 2, it can be observed that the removal efficiency for the following elements can reach:

- suspended solids: up to 98%
- total phosphorous: up to 98%
- 5 - total nitrogen: up to 60%
- total coliforms: up to 99%

The condition of the electrodes can be defined by the following relation:

$$10 \quad \Phi(t) = \frac{\text{rate of reaction of the proton at the electrodes surface at } t}{\text{rate of reaction of the proton at the electrodes surface at } t = 0}$$

Physically, the parameter  $\Phi$  represents the surface of an active site available on an electrode (namely the cathode) expressed in a non-dimensional  
 15 number for an electrochemical reaction. The higher the non-dimensional number  $\Phi$  is, the more the active sites are plentiful. In other words, the electrode is in a very clean state. On the other hand, a low value of  $\Phi$  (below 0.5) provides an indication that less and less number of active sites are available, thereby indicating that the electrode has to be cleaned or changed. A  $\Phi$  value comprised  
 20 between 0.5 and 0.8 indicates a normal operating condition of the electrodes.

Fig. 9 describes the evolution of the condition of the electrodes  $\Phi$  as a function of time. At the beginning, the electrode is in a very clean condition. Despite the various variations of the composition at the inlet of the reactor, notably the important fluctuations of the suspended matters, the condition of the  
 25 electrodes remains in a normal operating condition (points 21–46). On the other hand, when the suspended solids reach a critical threshold ( $\geq 3000$ -10000 mg/L), the electrode is in a worn out state (point 51). Despite everything, the condition of the electrodes is continuously renewed as a result of the re-circulation process of the purified water which provides for a progressive removal of the dirt from the  
 30 electrodes (points 51 –92).

The condition of the electrodes can be monitored and cleaned as required by at least one of the following modes:

- 1) A rapid increase of the current intensity at the beginning of the reaction by the control unit and the return to a normal point of operation after a little while (after a few seconds or a few minutes);
- 2) by ultrasound;
- 3) by mechanical means; and
- 4) by changing the polarity.

10 Table 1: Experimental Conditions for trials in synthetic water

Block No	Current Density (A/m <sup>2</sup> )	Electric Field (V/m)	Conduct. (S/cm)	Temp (°C)
1	93	645	2.135	19.1
2	93	590	2.15	20.5
3	93	496	2.2	20.2
4	93	512	2.04	19.7
5	186	961.5	2.18	21.4
6	279	14200	2.23	23.2
7	232	11420	2.26	22.8
8	279	14600	2.12	21.6



Table 2:

#	Total phosphorus (mg/L)		Total nitrogen (mg/L)		Suspended solids (mg/L)	
	IN	OUT	IN	OUT	IN	OUT
1	57.0	5.75	52.5	40	634	20
2	135.0	4.2	360	235	2750	60
3	89.5	1.9	50.0	42.5	225	10
4	74.0	2.75	70	27.5	167	10
5	84.3	5.75	67.5	42.5	300	40
6	77.0	1.63	73	50	133	40
7	73.0	1.25	87.5	65.0	200	40
8	143	5.25	200.0	55.0	2600	100
9	86.0	3.0	n.m.	n.m	120	10
10	107.0	3.0	95.0	80.	632	200
11	83.0	4.9	117.5	77.3	800	150
12	92.5	5.5	90.0	65.	800	75
13	61.5	5.3	75.0	67.5	450	38
14	69.1	3.1	97.5	90.	150	133
15	69.0	3.0	87.5	80.0	650	20
16	65.5	3.5	72.5	50.	300	40.
17	88.0	4.3	80.0	65.0	400.	33
18	143.5	5.3	132.5	65.0	1500	125
19	42.0	4.3	70.0	60.0	300	33
Average	86.3	3.9	104.3	69.9	690.1	61.9
Minimum	42.0	1.25	50.0	27.5	120	10
Maximum	143.5	5.75	360.0	235.0	2750	200

## CLAIMS:

1. An apparatus for electrochemical purification of a contaminated aqueous medium, comprising at least one electrochemical reactor and a re-circulation system for causing at least a portion of the aqueous medium to flow back into the electrochemical reactor after the contaminated aqueous medium has been treated and at least partially cleaned.
2. An apparatus as defined in claim 1, wherein a settling chamber is connected in fluid flow communication with the at least one electrochemical reactor.
3. An apparatus as defined in claim 1, further including an air diffuser for injecting air in the fluid flowing through the electrochemical reactor.
4. An apparatus as defined in claim 1, wherein said electrochemical reactor includes a series of electrodes, and wherein an ultrasound generator is provided for emitting vibrations to cause dirt on said electrodes to fall therefrom.
5. An apparatus as defined in claim 3, wherein the electrochemical reactor includes a chamber and an electrochemical cell mounted inside said chamber, said air diffuser injecting air into said chamber at a location below said electrochemical cell.
6. An apparatus as defined in claim 2, wherein an air diffuser is provided for injecting air into said settling chamber.
7. An apparatus as defined in claim 2, wherein said apparatus comprises first and second electrochemical reactors, said first reactor having a first inlet connected to an outlet end of said re-circulation system, said second electrochemical reactor having a second inlet connected in fluid flow

communication with a first outlet of said first electrochemical reactor, said second electrochemical reactor has a second outlet connected in fluid flow communication with said settling chamber for allowing the aqueous medium to flow from said second reactor to said settling chamber, and wherein said re-circulation system has an inlet end for allowing the aqueous medium to be re-circulated for a predetermined period of time through the first reactor, the second reactor and the settling chamber.

8. An apparatus as defined in claim 2, wherein said apparatus comprises first and second electrochemical reactors, said first reactor having a first inlet connected to an outlet end of said re-circulation system and a first outlet connected to an inlet of said settling chamber, said second electrochemical reactor having a second inlet connected in fluid flow communication with an outlet of said settling chamber, and wherein said re-circulation system has an inlet end for allowing the aqueous medium to be re-circulated for a predetermined period of time through the first reactor, the second reactor and the settling chamber.

9. An apparatus as defined in claim 1, wherein said inlet end of said re-circulation system is connected in fluid flow communication with a clear aqueous medium collection compartment.

10. An apparatus as defined in claim 1, further comprising a mechanical separation system for cooperating with said electrochemical reactor in purifying the aqueous medium.

11. An apparatus as defined in claim 9, wherein said separation system is integrated to the re-circulation system to obtain a relatively clear liquid that is re-circulated through the electrochemical reactor by said re-circulation system.

12. An apparatus as defined in claim 10, wherein a by-pass is provided for selectively allowing the aqueous medium to be directly re-circulated into the electrochemical reactor without passing through the separation system.

13. An apparatus as defined in claim 7, wherein said second inlet and said second outlet are configured to cause the aqueous medium to flow through said second reactor in a direction opposite to a direction of flow of the aqueous medium in the first reactor.

14. An apparatus as defined in claim 13, wherein said first inlet and said first outlet are respectively provided at lower and upper end portions of said first reactor, whereas said second inlet and said second outlet of said second reactor are respectively provided at upper and lower end portions of said second reactor, thereby causing the aqueous medium to flow upwardly through said first reactor and then downwardly through said second reactor.

15. An apparatus as defined in claim 13, wherein said first and second reactors are adapted to interchangeably receive one of an electrofloatation cell and an electrocoagulation cell, thereby allowing electrofloatation and electrocoagulation treatments to be selectively performed with a co-current or counter-current flow of aqueous medium depending in which of the first and second reactors the electrofloatation cell and the electrocoagulation cell are respectively installed.

16. A method for separating contaminants from a contaminated effluent, comprising the steps of: feeding the contaminated effluent to be treated into an apparatus comprising at least one electrochemical reactor and a re-circulation system, submitting the contaminated effluent to a succession of electrochemical treatments by re-circulating the contaminated effluent through the apparatus for a predetermined period of time to obtain an agglomeration of the

contaminants contained in the effluent, and evacuating the agglomerated contaminants.

17. A method as defined in claim 16, further comprising the step of: injecting air bubbles into the contaminated effluent flowing through at least one of the electrochemical reactor and the settling chamber.

18. A method as defined in claim 16, further comprising the step of: selectively connecting the electrochemical reactor and the settling chamber in a closed re-circulation circuit with a mechanical separator.

19. A method as defined in claim 18, wherein a by-pass is provided for allowing the contaminated effluent to be re-circulated through the electrochemical reactor without passing through the mechanical separator.

20. An electrochemical treatment device for treatment of a contaminated effluent, comprising a recirculation circuit for circulating said effluent through a closed loop, an electrochemical reactor and a mechanical separator integrated to said closed loop for gradually purifying the effluent each time the effluent is circulated therethrough.

21. A device as defined in claim 20, wherein a by-pass is provided for selectively disconnecting the mechanical separator from the re-circulation circuit, thereby allowing the effluent to be only re-circulated through the reactor.

22. A device as defined in claim 21, wherein said mechanical separator includes a filtration membrane unit.

23. A device as defined in claim 20, wherein a settling chamber is connected in fluid flow communication with said mechanical separator and said electrochemical reactor.

24. An electrochemical cell comprising a set of electrode plates mounted between a pair of opposed non-conductive walls defining on respective inner faces thereof a series of longitudinally spaced-apart parallel slots for receiving opposed longitudinal edges of the electrode plates, thereby holding the electrode plates in a parallel spaced-apart relationship to one another.

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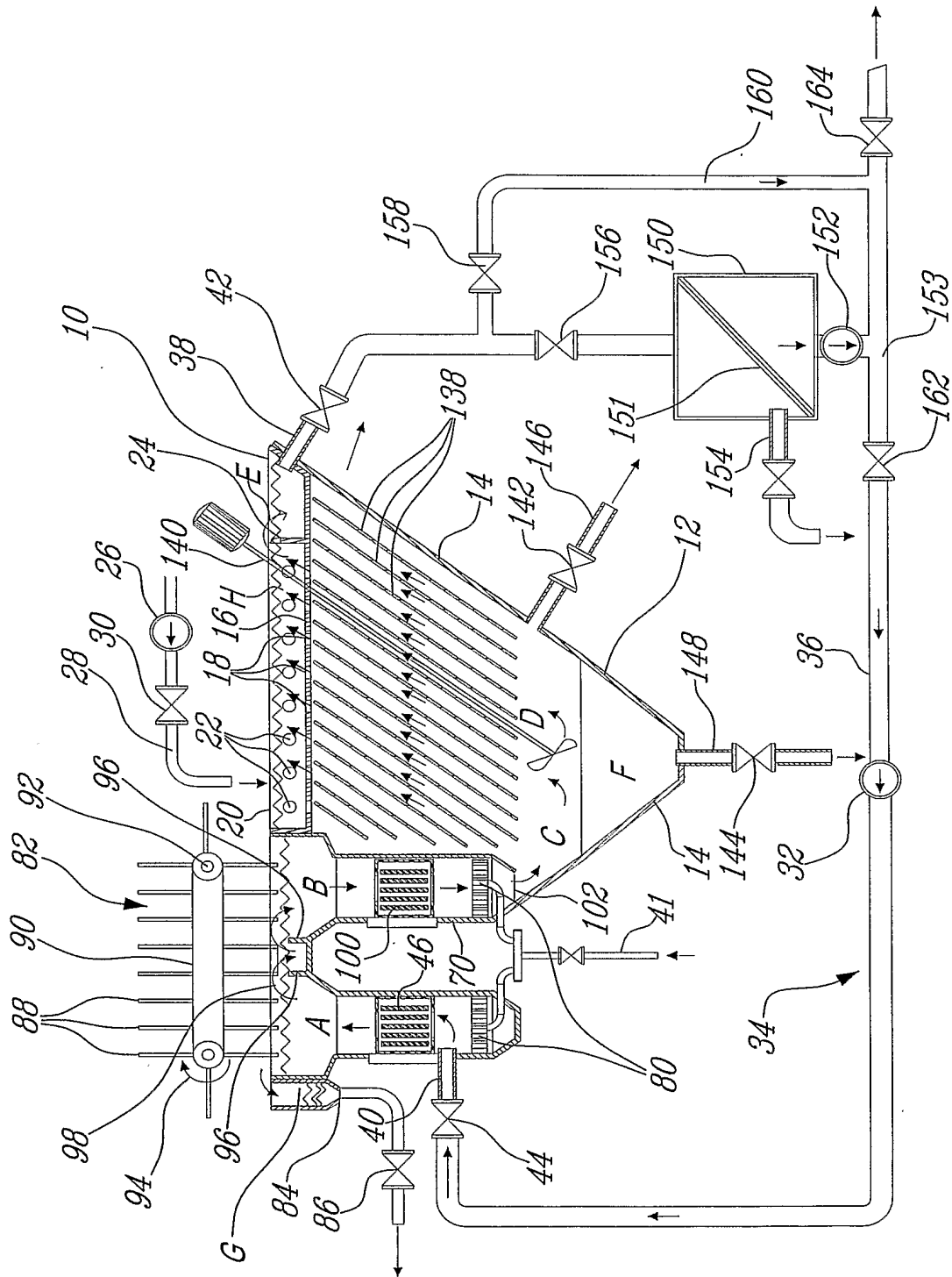


Fig. 1

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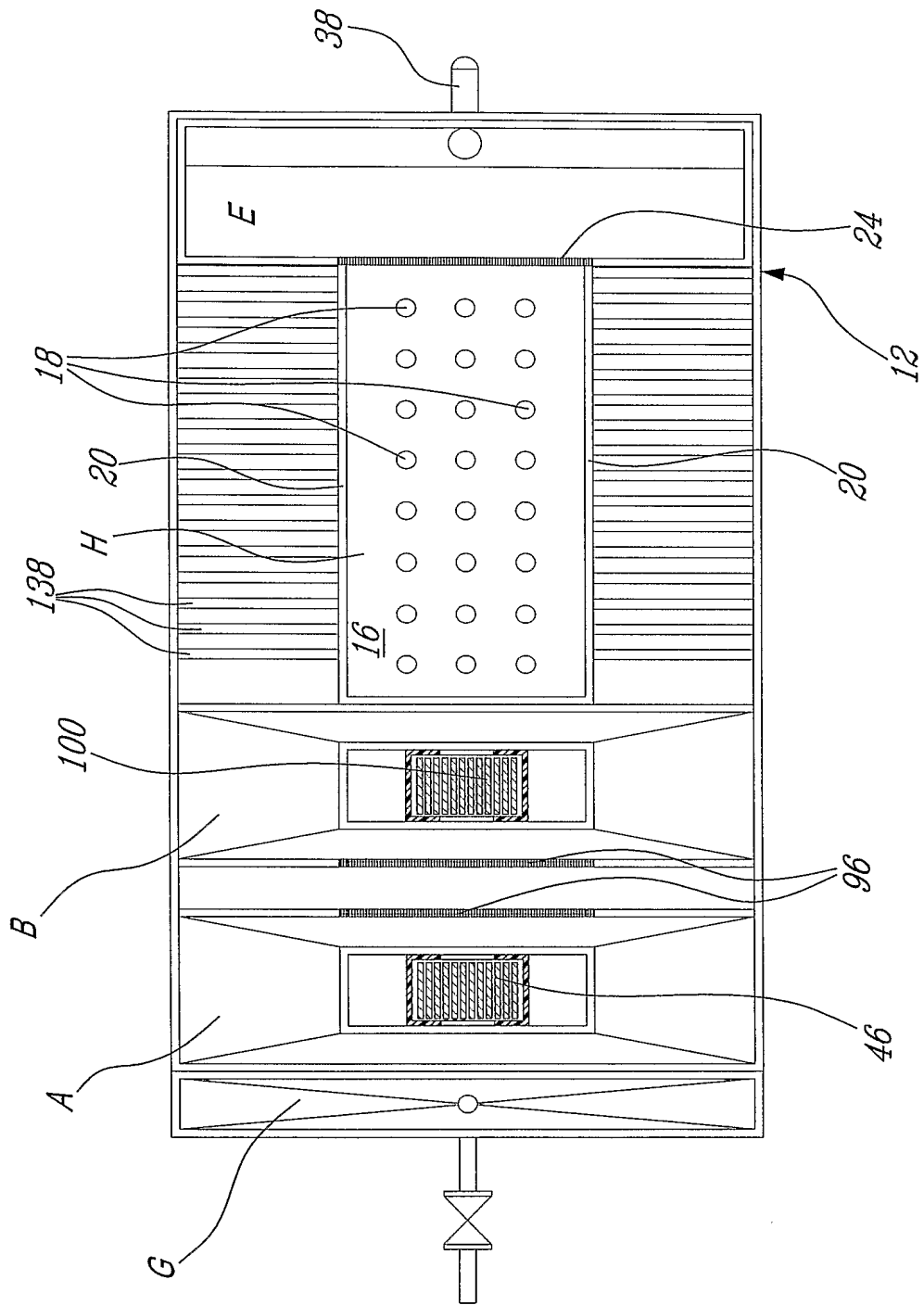
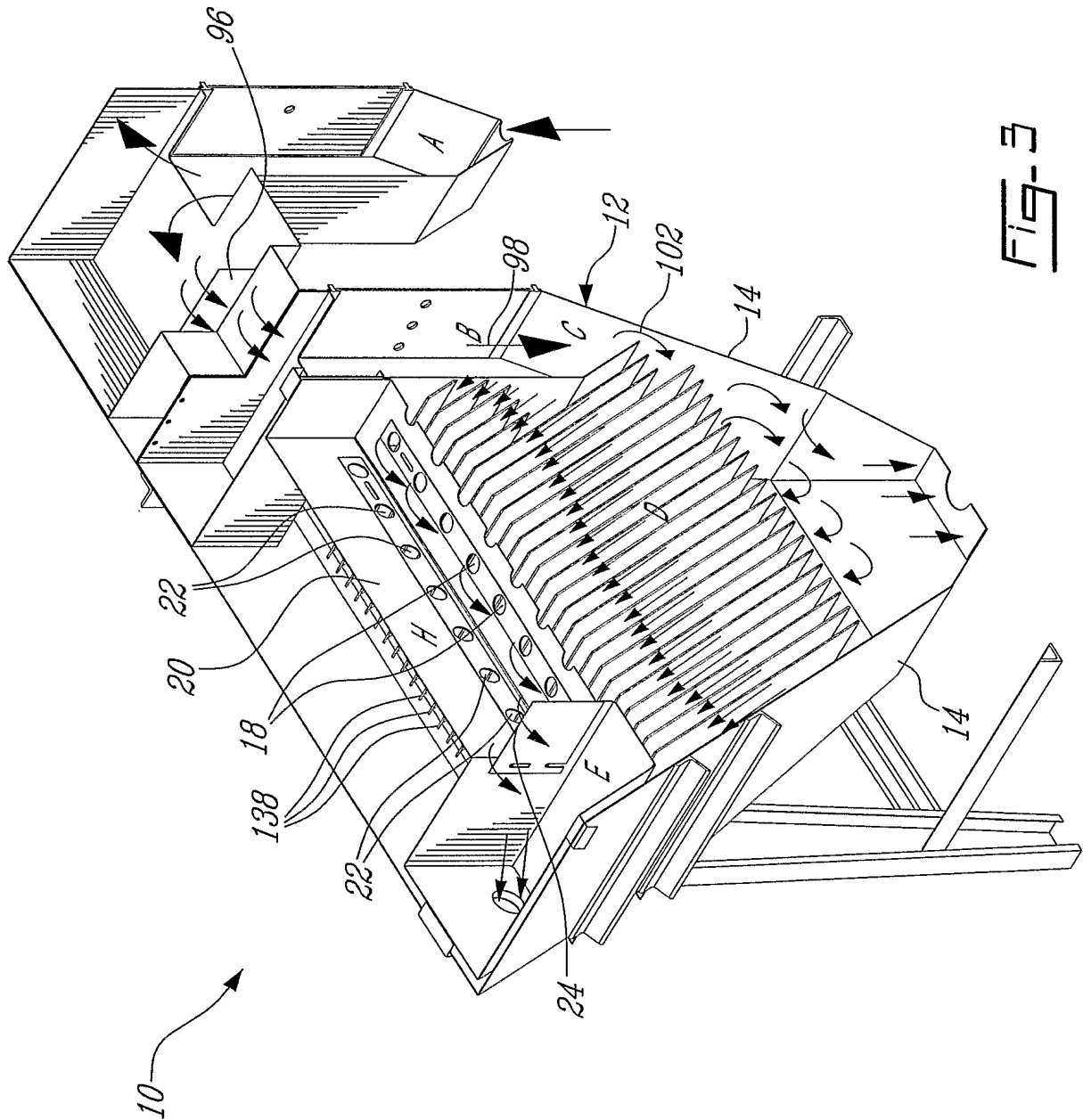


Fig-2



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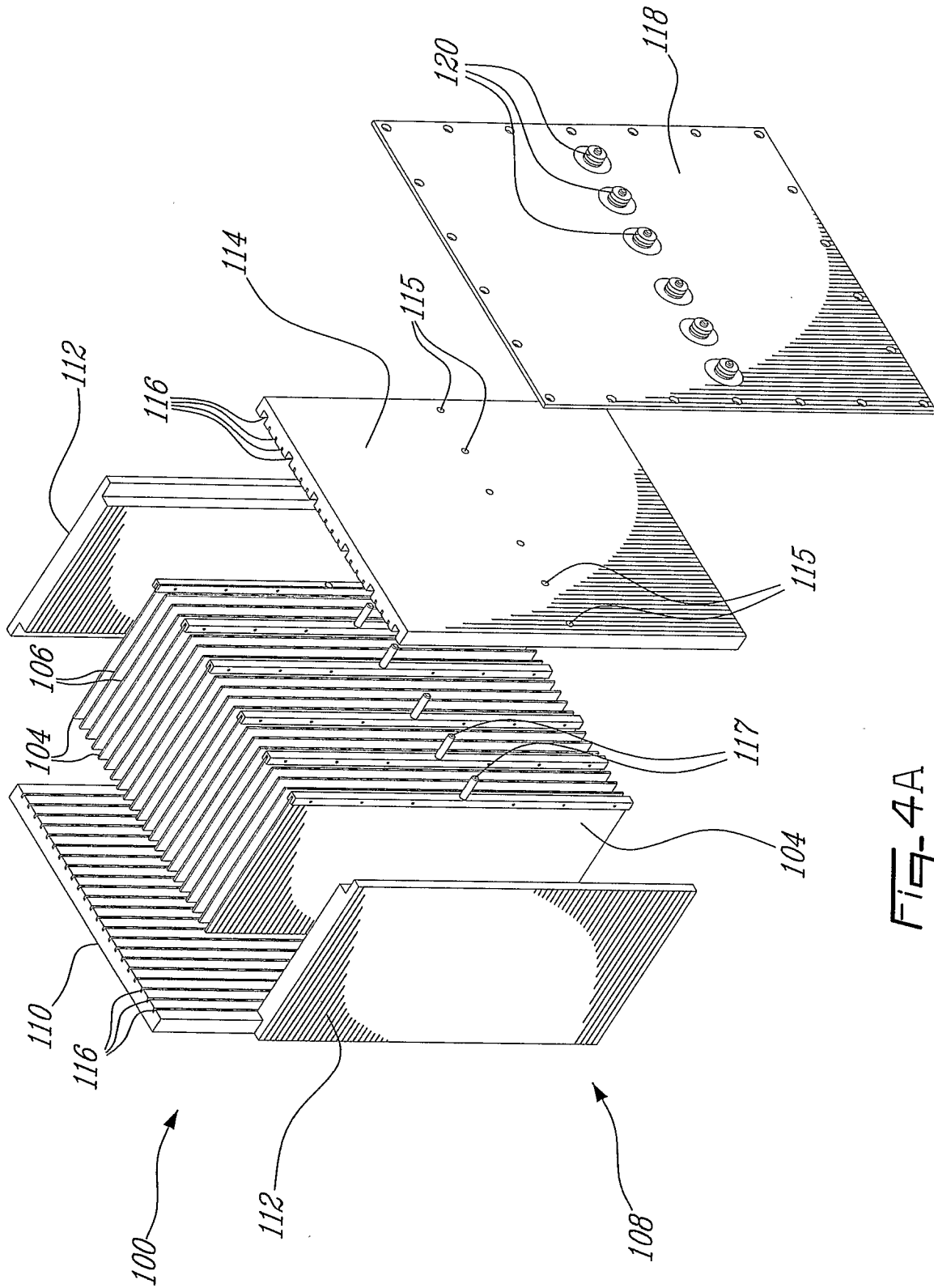
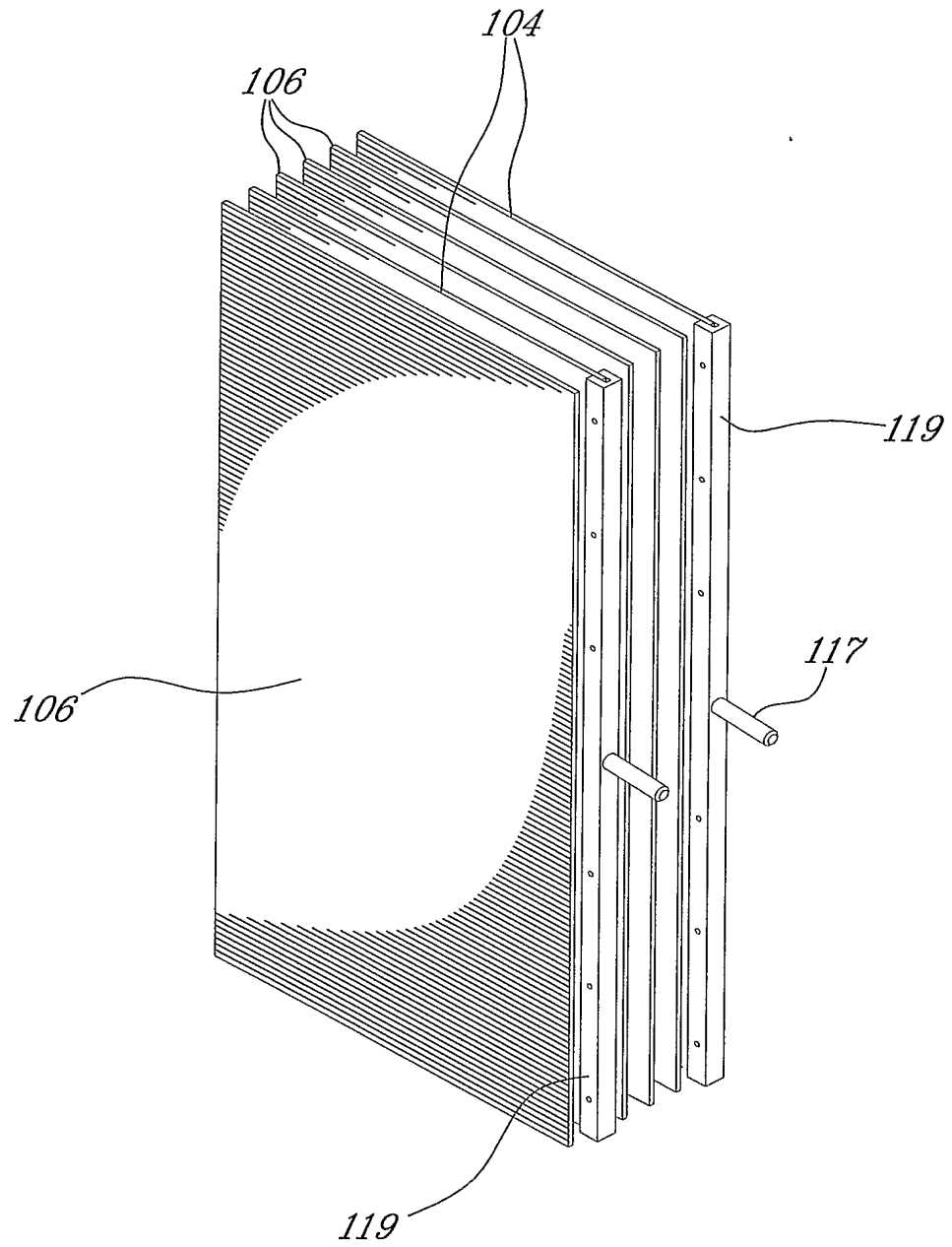


Fig-4A

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**FIG-4B**

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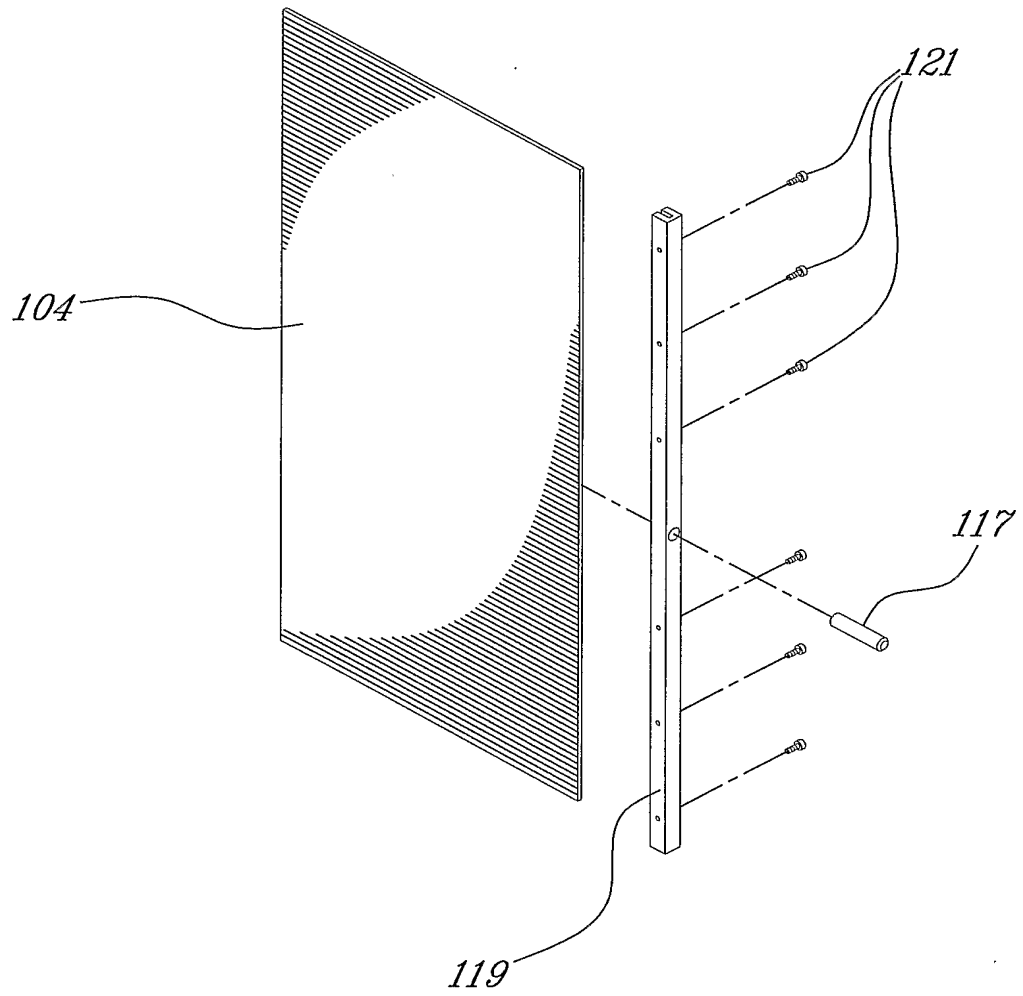


Fig-4C

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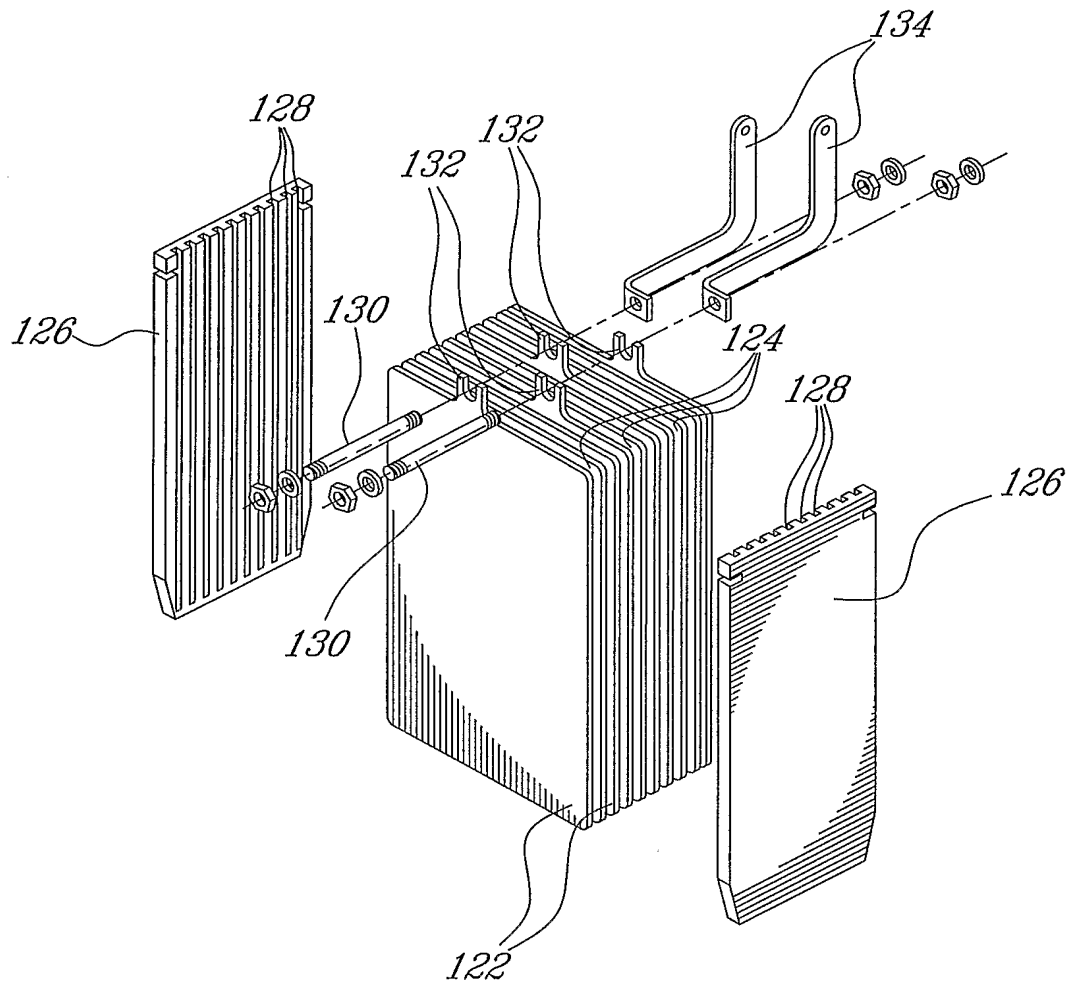


Fig-5

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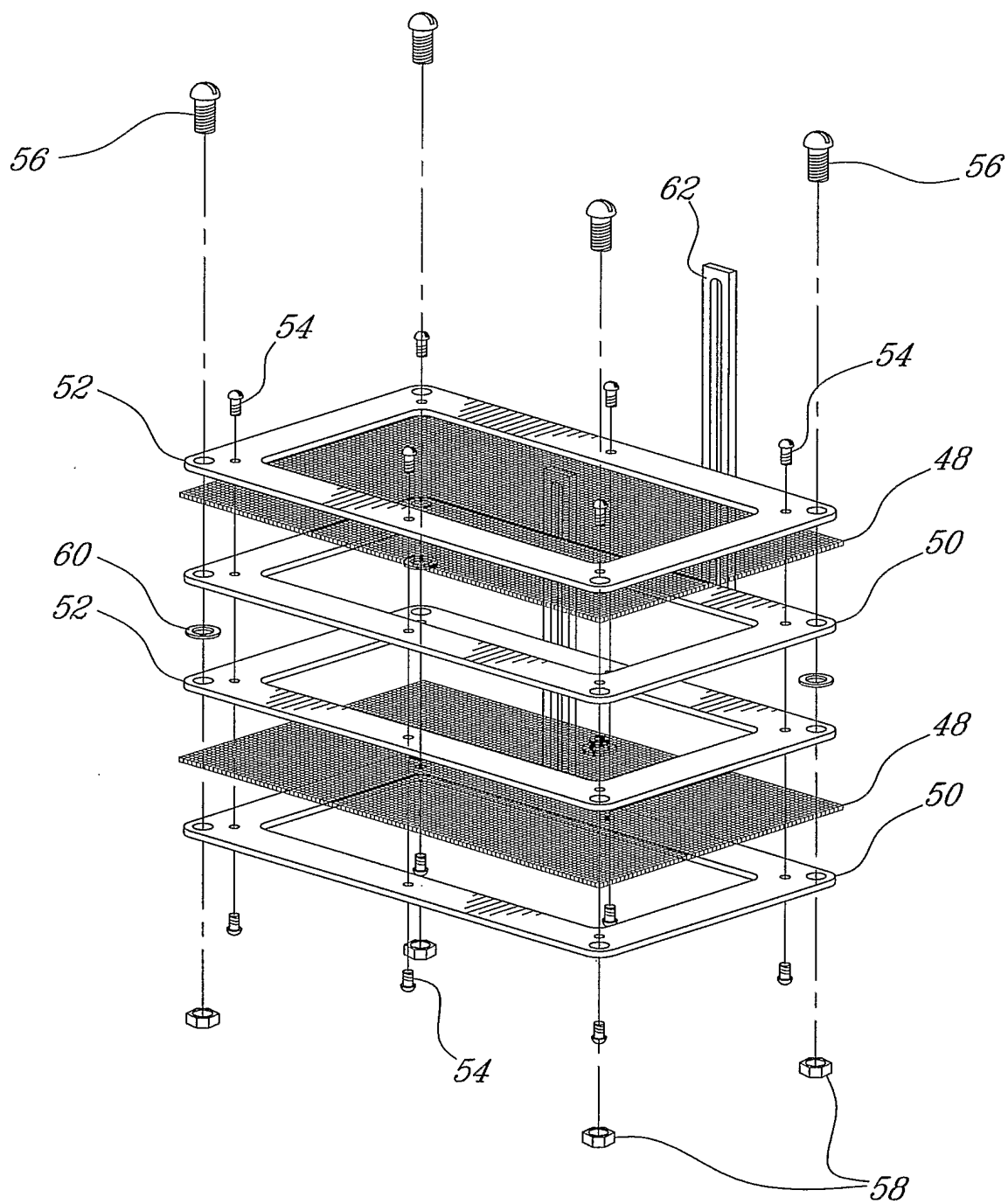


FIG-6

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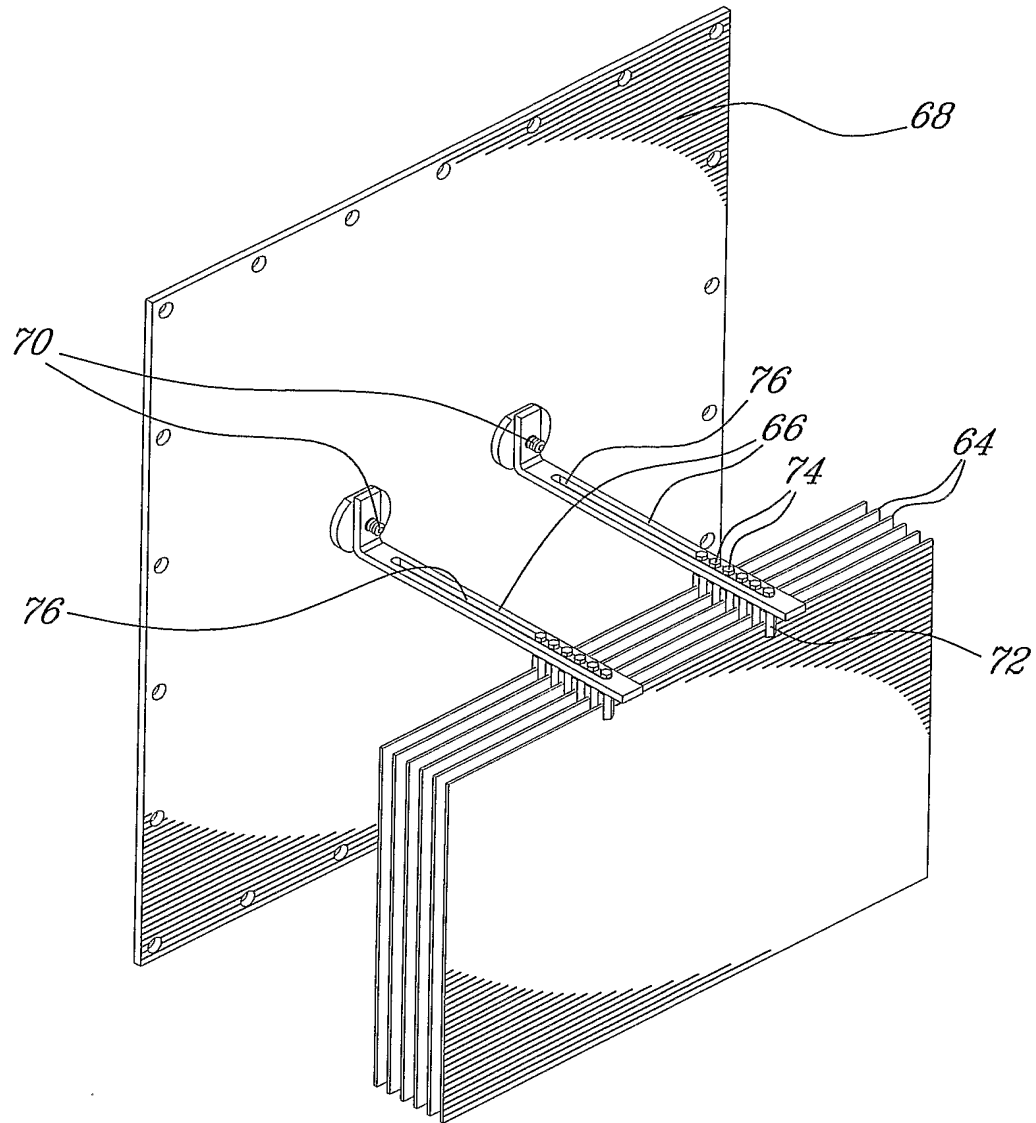


FIG-7A

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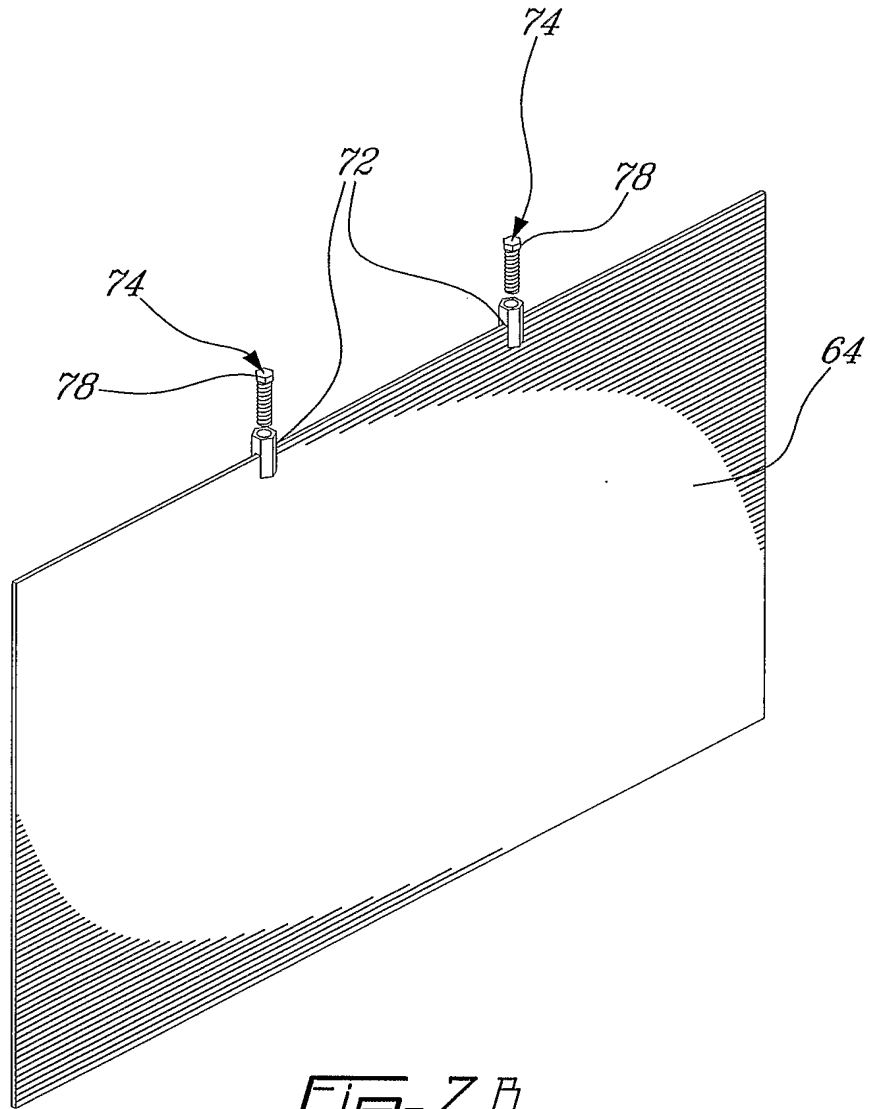


FIG-7 B



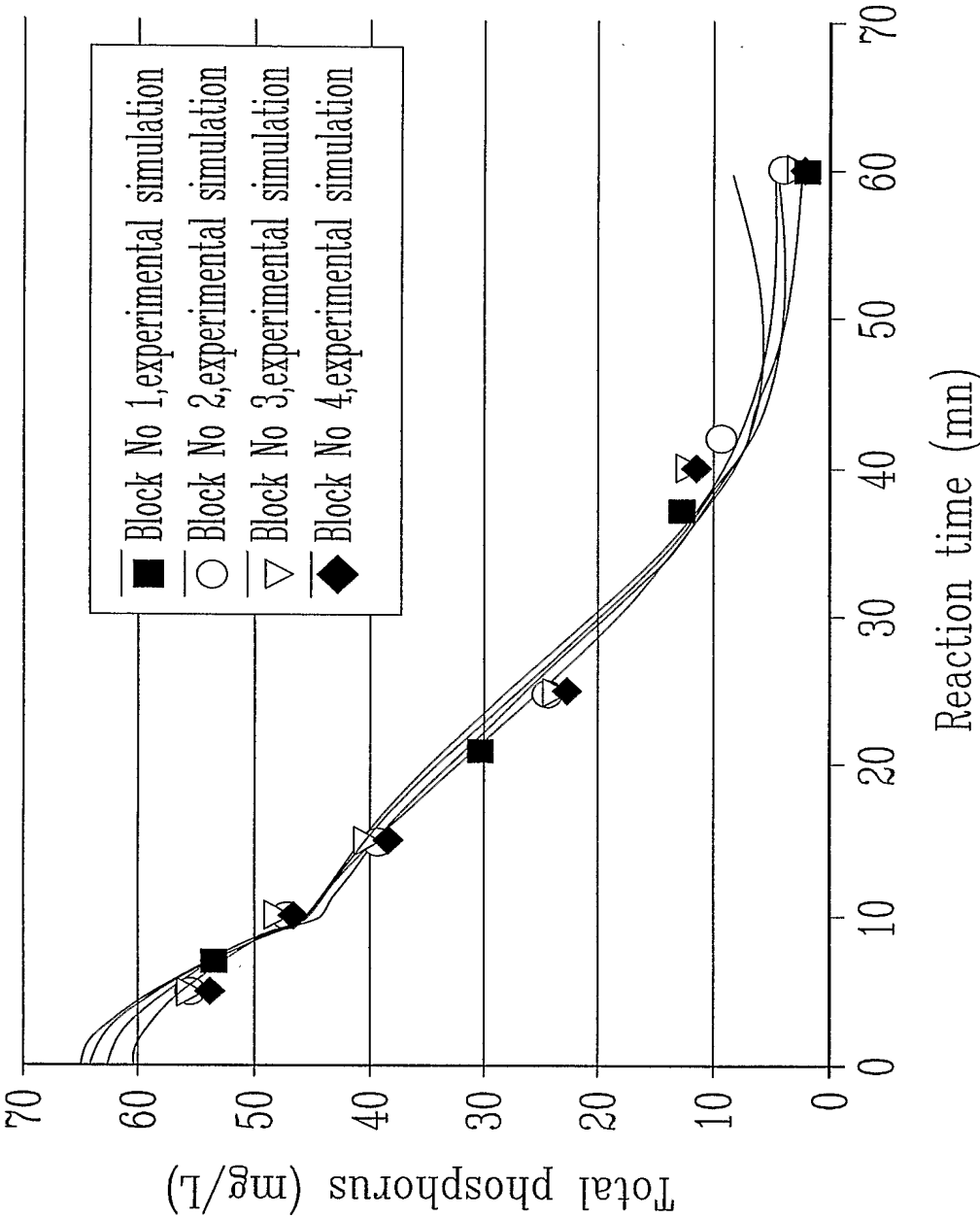


Fig-8A

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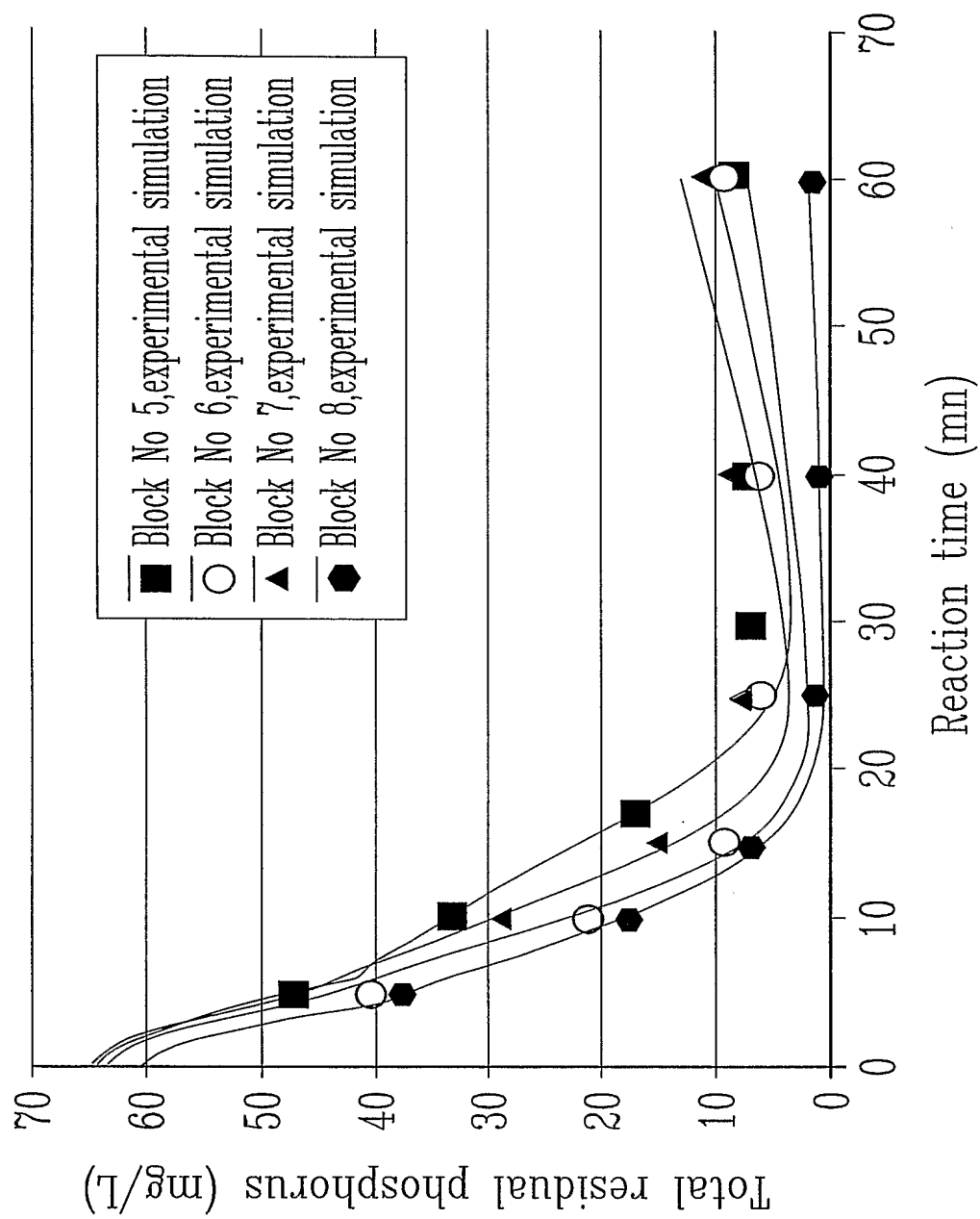
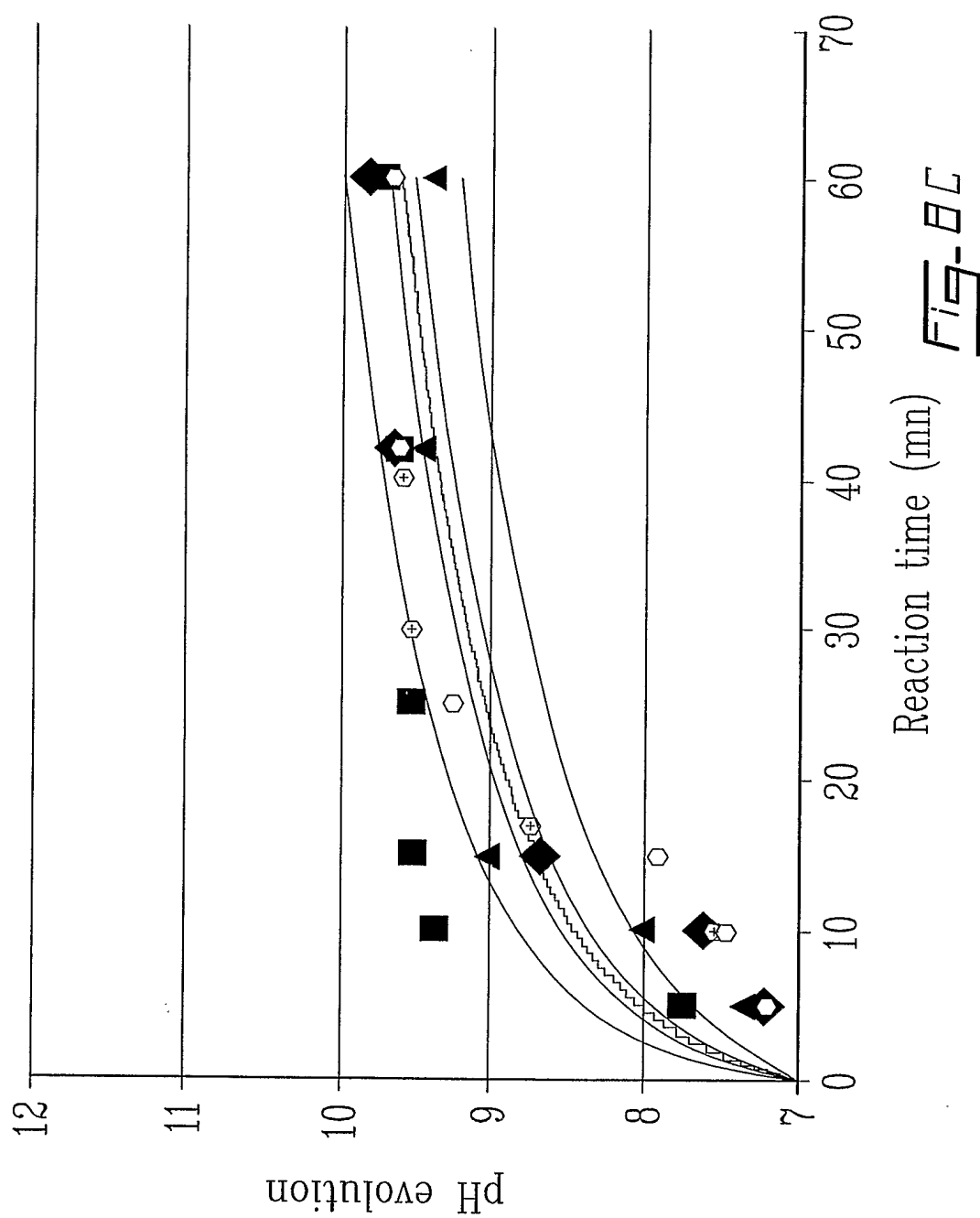


Fig. 8 B

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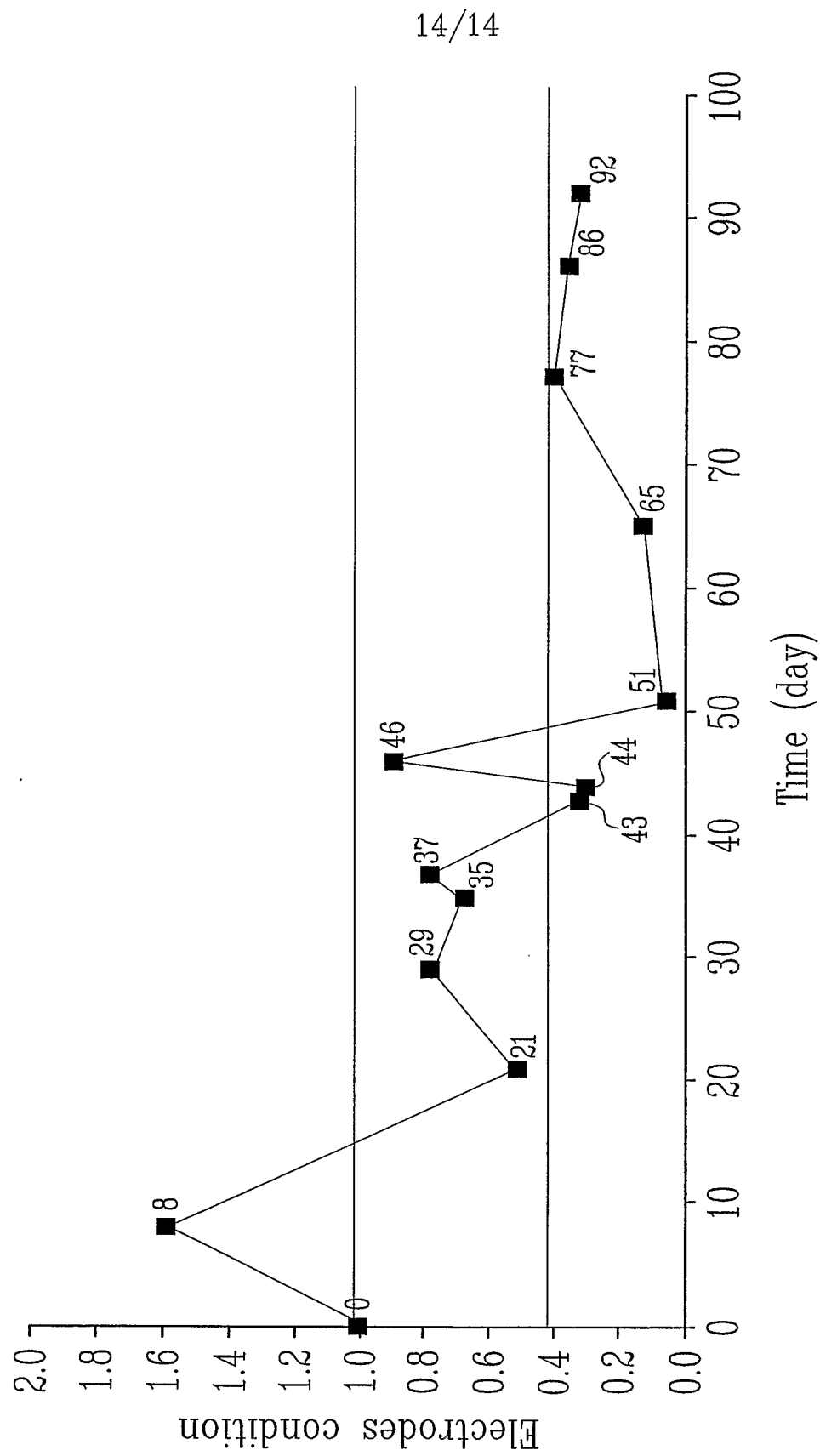


Fig-9

PCT/CA 03/02005

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/CA 03/02005

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/020631 A1 (GAVREL TOM GUS ET AL) 21 February 2002 (2002-02-21) page 2, paragraph 18; figure 1 page 3, paragraphs 24,28; figure 2 -----	1,2,16, 20,22
X	EP 0 761 603 A (IMEC VZW) 12 March 1997 (1997-03-12) column 4, line 11 - line 23; figure 1 -----	1,2,16, 20
A	GIDARAKOS E ET AL: "ENTSORGUNG VON OL-IN-WASSER-EMULSIONEN DURCH ELEKTROKOAGULATION" CHEMIE. INGENIEUR. TECHNIK, VERLAG CHEMIE GMBH. WEINHEIM, DE, vol. 61, no. 6, 1 June 1989 (1989-06-01), pages 443-448, XP000069304 ISSN: 0009-286X the whole document -----	1-24

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/CA 03/02005

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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			AU 6329296 A	30-12-1996
			WO 9640591 A1	19-12-1996
			AU 2273695 A	10-11-1995
			WO 9528355 A1	26-10-1995
FR 2707282	A	13-01-1995	FR 2707282 A1	13-01-1995
US 2002036172	A1	28-03-2002	IT MI20001631 A1	18-01-2002
US 2002020631	A1	21-02-2002	NONE	
EP 0761603	A	12-03-1997	EP 0761603 A1	12-03-1997

**DERWENT-ACC-NO:** 2004-507680**DERWENT-WEEK:** 200562*COPYRIGHT 2009 DERWENT INFORMATION LTD*

**TITLE:** Apparatus for treatment of  
contaminated liquids e.g. wastewater  
comprises electrochemical reactor and  
re-circulation system for causing a  
portion of the liquid to flow back  
into the reactor after the liquid has  
been partially cleaned

**INVENTOR:** CHABOT R; COMEAU Y ; DUTIL C ; GALLOT J ;  
GALLOT J M ; ZEGAN D

**PATENT-ASSIGNEE:** ENVIROGAIN INC[ENVIN]

**PRIORITY-DATA:** 2002US-435266P (December 23, 2002)

**PATENT-FAMILY:**

<b>PUB-NO</b>	<b>PUB-DATE</b>	<b>LANGUAGE</b>
WO 2004056711 A1	July 8, 2004	EN
AU 2003292932 A1	July 14, 2004	EN
EP 1575876 A1	September 21, 2005	EN



**DESIGNATED-STATES:** AE AG AL AM AT AU AZ BA BB BG BR BW  
 BY BZ CA CH CN CO CR CU CZ DE DK DM  
 DZ EC EE EG ES FI GB GD GE GH GM HR  
 HU ID IL IN IS JP KE KG KP KR KZ LC  
 LK LR LS LT LU LV MA MD MG MK MN MW  
 MX MZ NI NO NZ OM PG PH PL PT R O  
 RU SC SD SE SG SK SL SY TJ TM TN TR  
 TT TZ UA UG US UZ VC VN YU ZA ZM ZW  
 AT BE BG BW CH CY CZ DE DK EA EE ES  
 FI FR GB GH GM GR HU IE IT KE LS LU  
 MC MW MZ NL OA PT RO SD SE SI SK SL  
 SZ TR TZ UG ZM ZW AL AT BE BG CH CY  
 CZ DE DK EE ES FI FR GB GR HU IE IT  
 L I LT LU LV MC MK NL PT RO SE SI  
 SK TR

**APPLICATION-DATA:**

<b>PUB-NO</b>	<b>APPL- DESCRIPTOR</b>	<b>APPL-NO</b>	<b>APPL-DATE</b>
WO2004056711A1	N/A	2003WO- CA02005	December 22, 2003
AU2003292932A1	N/A	2003AU- 292932	December 22, 2003
EP 1575876A1	N/A	2003EP- 788733	December 22, 2003
EP 1575876A1	Based on	2003WO- CA02005	December 22, 2003

**INT-CL-CURRENT:**

<b>TYPE</b>	<b>IPC DATE</b>
CIPS	C02F1/463 20060101

**ABSTRACTED-PUB-NO:** WO 2004056711 A1

**BASIC-ABSTRACT:**

NOVELTY - An apparatus (10) comprises at least one electrochemical reactor (A, B) and a re-circulation system (34) for causing at least a portion of the aqueous medium to flow back into the electrochemical reactor after contaminated aqueous medium has been treated and at least partially cleaned in a settling chamber (D). The settling chamber is connected to at least one electrochemical reactor.

DESCRIPTION - The apparatus further includes an air diffuser (80) for injecting air in the fluid flowing through the electrochemical reactor. INDEPENDENT CLAIMS are included for the following:

(1) method for separating contaminants from a contaminated effluent; and

(2) an electrochemical cell.

USE - For separating contaminants from contaminated effluent; for purification of contaminated effluent or aqueous medium (claimed) such as livestock (e.g. liquid manure) and industrial wastewater especially from agricultural industries or effluents which have gone through preliminary biological purification treatment; for oxidation of non-biodegradable organic residual loads and for destruction of pathogenic germs.

ADVANTAGE - The apparatus prevents the electrodes of the reactors from fouling; can operate in small room area and efficiently removes suspended solids, colloids, organic matters, pathogens, particulate and soluble phosphorus present in wastewater.

DESCRIPTION OF DRAWING(S) - The figure shows a schematic vertical cross-section view of an apparatus for the electrochemical treatment of contaminated liquids.

Apparatus (10)

Main tank (12)

Re-circulation pump (32)

Re-circulation system (34)

Electrofloatation cell (46)

Air diffuser (80)

Drain (84)

Electrocoagulation cell (100)

Separation system (150)

Suction pump (152)

Closing valve (156)

Opening valve (158)

Electrochemical reactor (A, B)

Settling chamber (D)

## **EQUIVALENT-ABSTRACTS:**

### **ELECTRICAL POWER AND ENERGY**

The electrochemical reactor includes a series of electrodes; an ultrasound generator for emitting vibrations to cause dirt on the electrodes to fall; a chamber and an electrochemical cell mounted inside the chamber.

**CHOSEN-DRAWING:** Dwg.1/14

**TITLE-TERMS:** APPARATUS TREAT CONTAMINATE LIQUID  
COMPRISE ELECTROCHEMICAL REACTOR  
CIRCULATE SYSTEM CAUSE PORTION FLOW  
BACK AFTER CLEAN

**DERWENT-CLASS:** D15 J03 X25

**CPI-CODES:** D04-A01; D04-A01M; D04-B; J03-B02;

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